Debris from dwarf satellites in the Auriga simulations

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and
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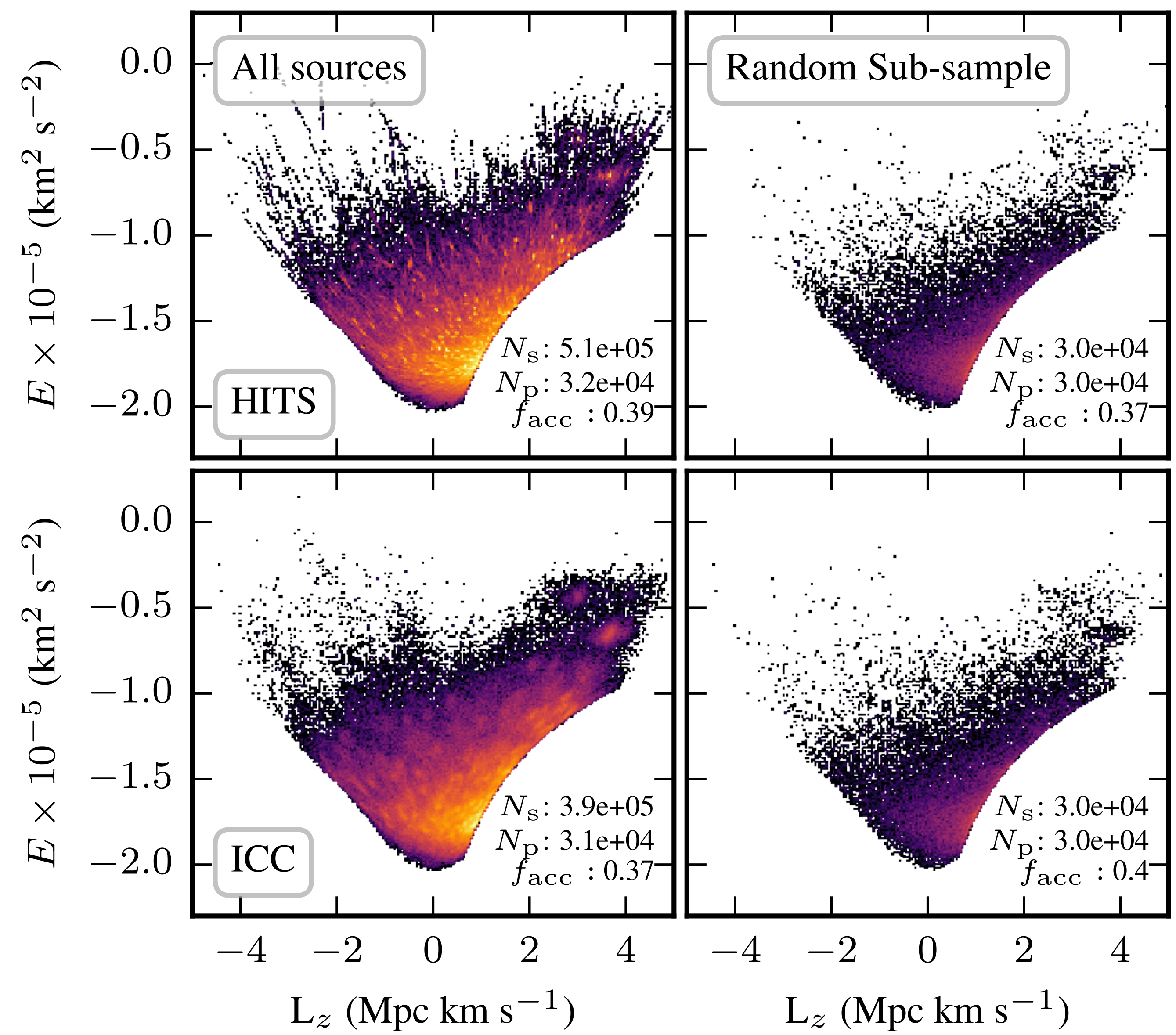
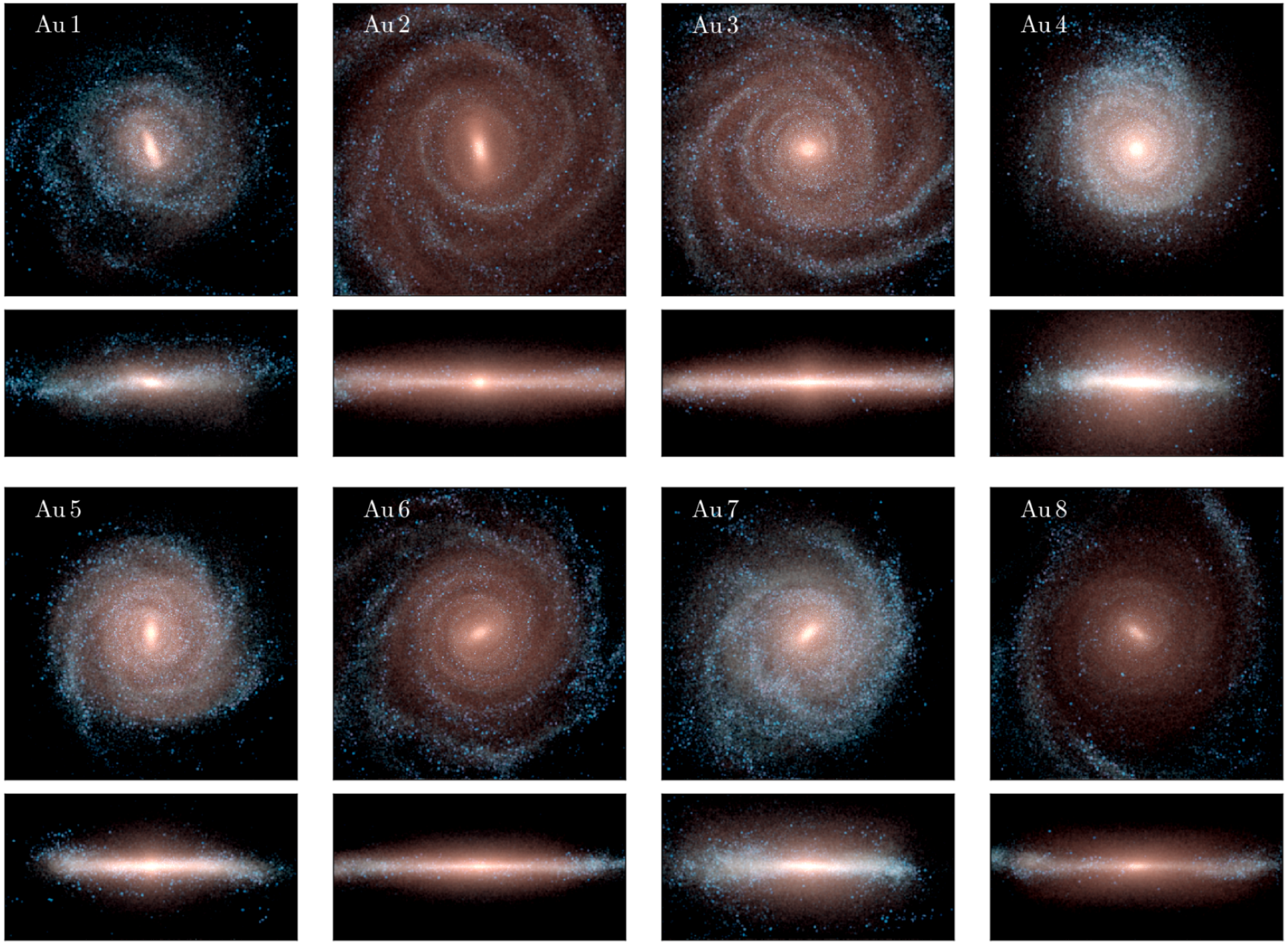


arXiv:1905.09842

AURIGA disks

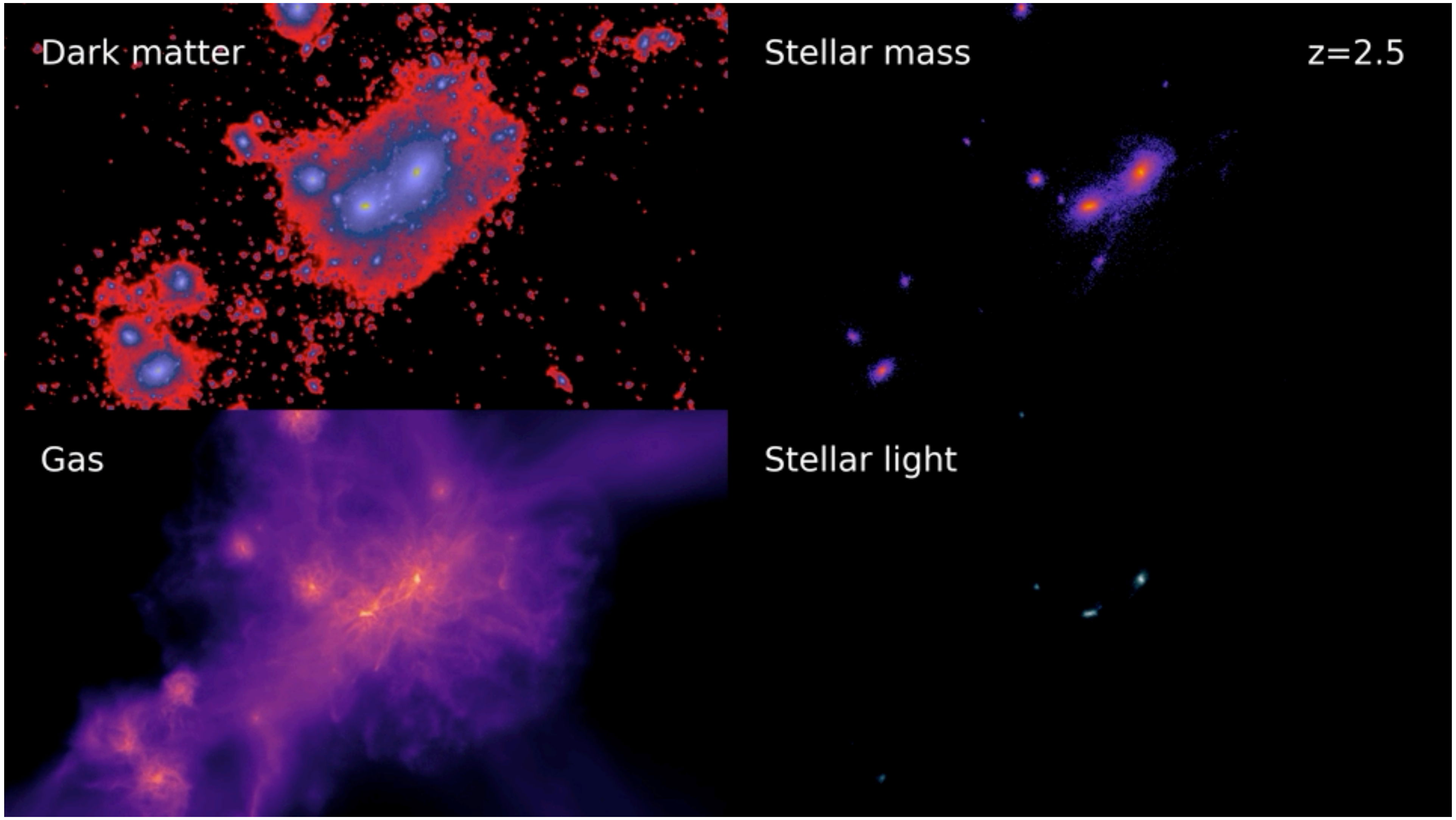
HIGH-RESOLUTION SIMULATIONS OF MILKY WAY-SIZED HALOS (Grand et al. 2017)



The Set-up & Physics

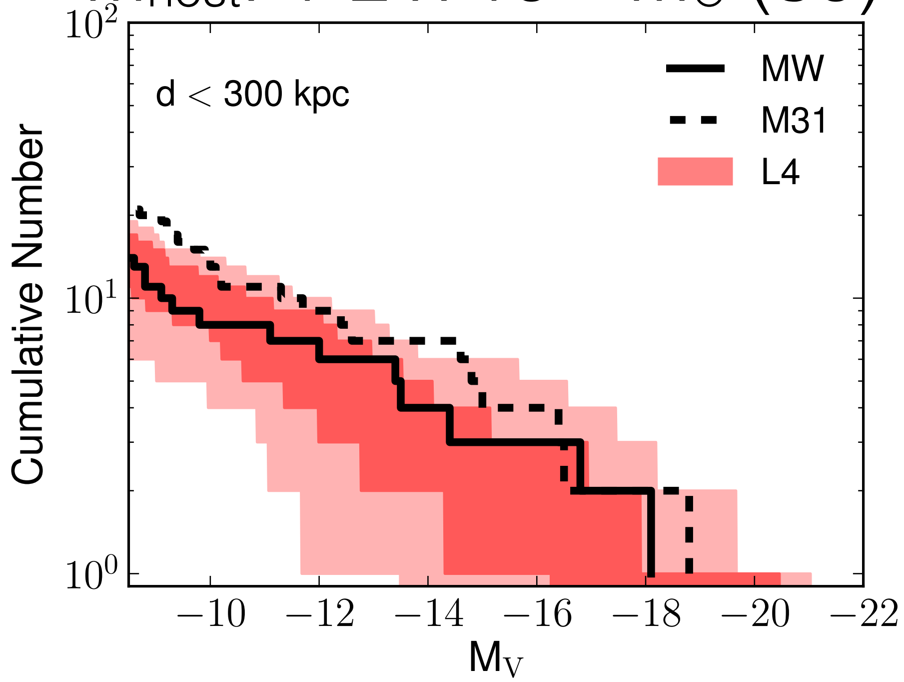
- Cosmological zoom simulations of 10^{12} $M_\odot$ halos
- baryon cell/particle mass ~6 x 10^3 $M_\odot$ for 6 halos; ~5 x 10^4 $M_\odot$ for 40 halos
- Second-order hydrodynamics on a moving mesh (AREPO)
- MHD, SF & stellar feedback, AGN feedback, UV background, atomic & metal line cooling

Satellites in Auriga

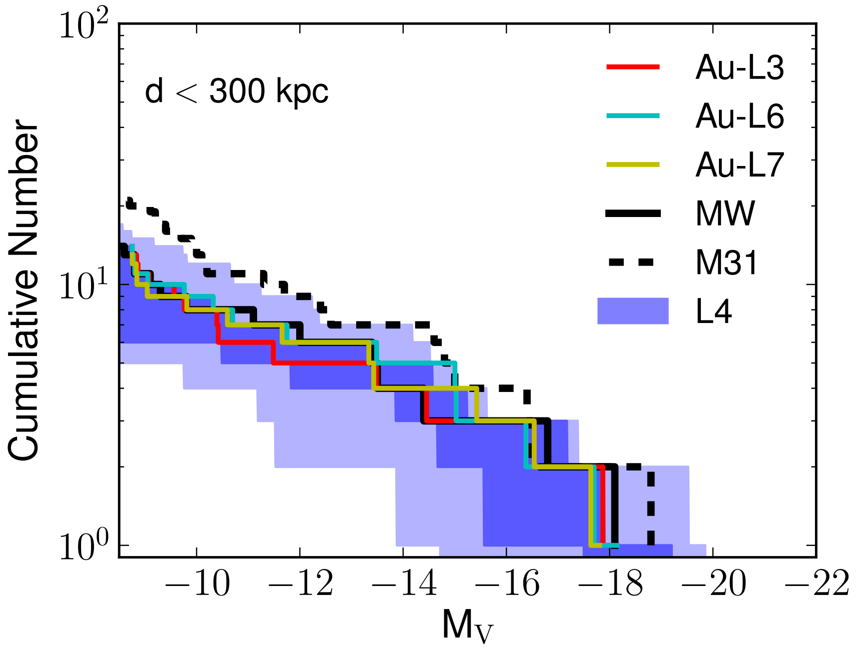


Surviving satellite Luminosity Functions

M_{host}: 1-2 x 10^{12} $M_{\odot}$ (30)

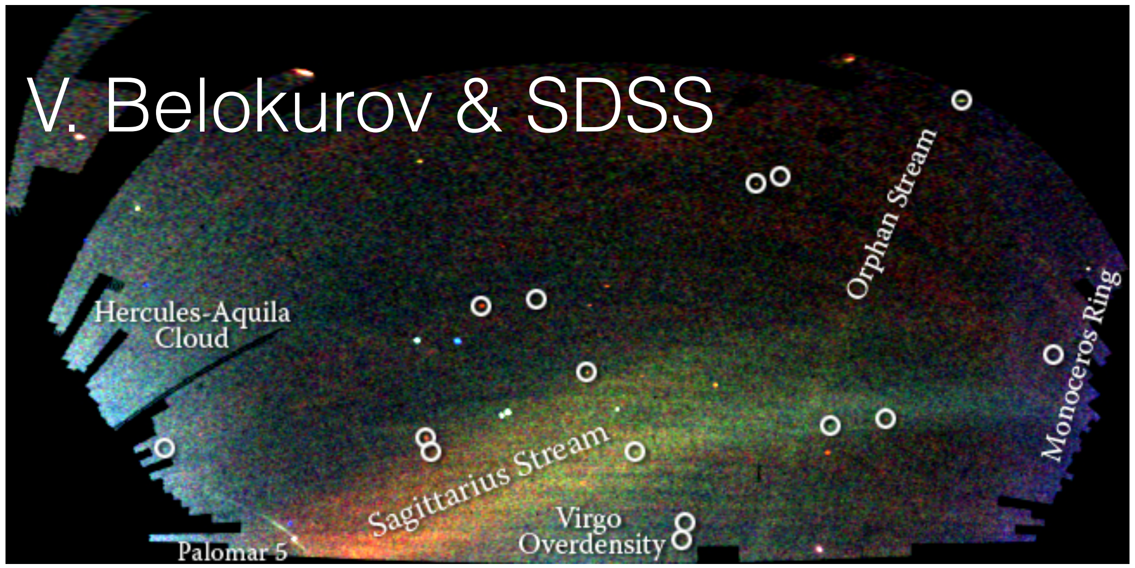


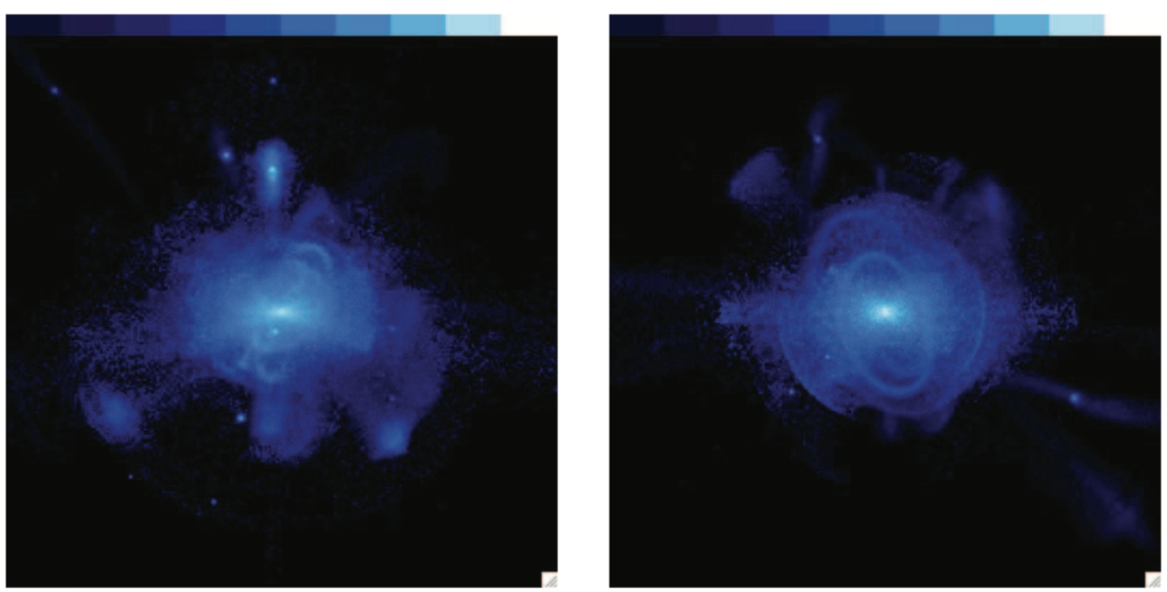
M_{host}: 0.5-1 x 10^{12} $M_{\odot}$ (10)



Many satellites don’t survive but they are still present in the Galaxy

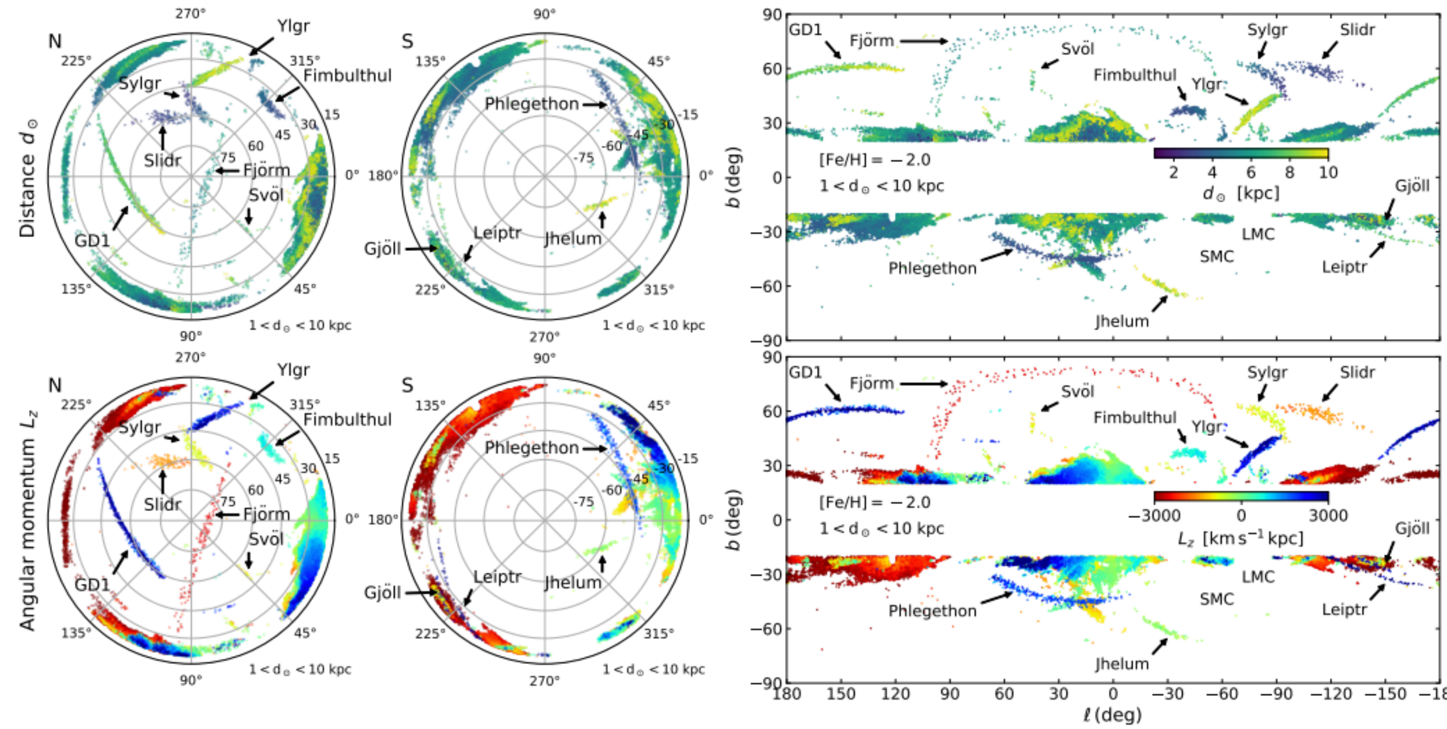
Pre-Gaia Picture



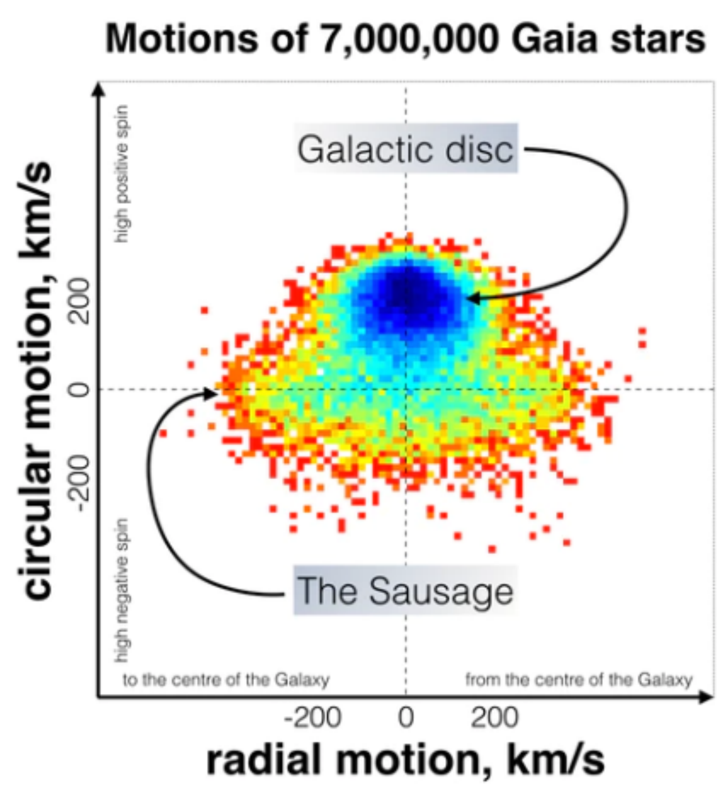


Bullock & Johnston 2005

New GAIA Picture



Ibata et al. 2019

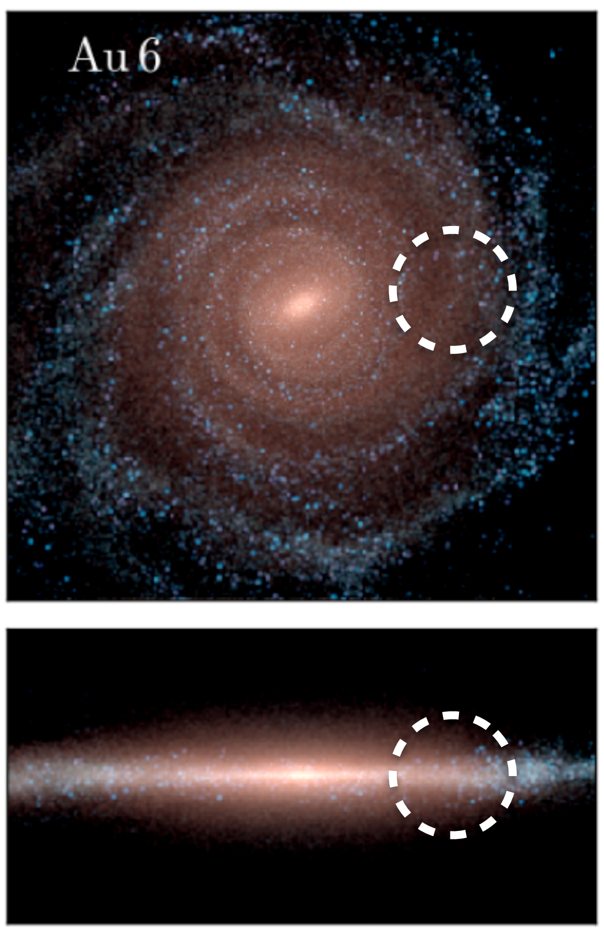


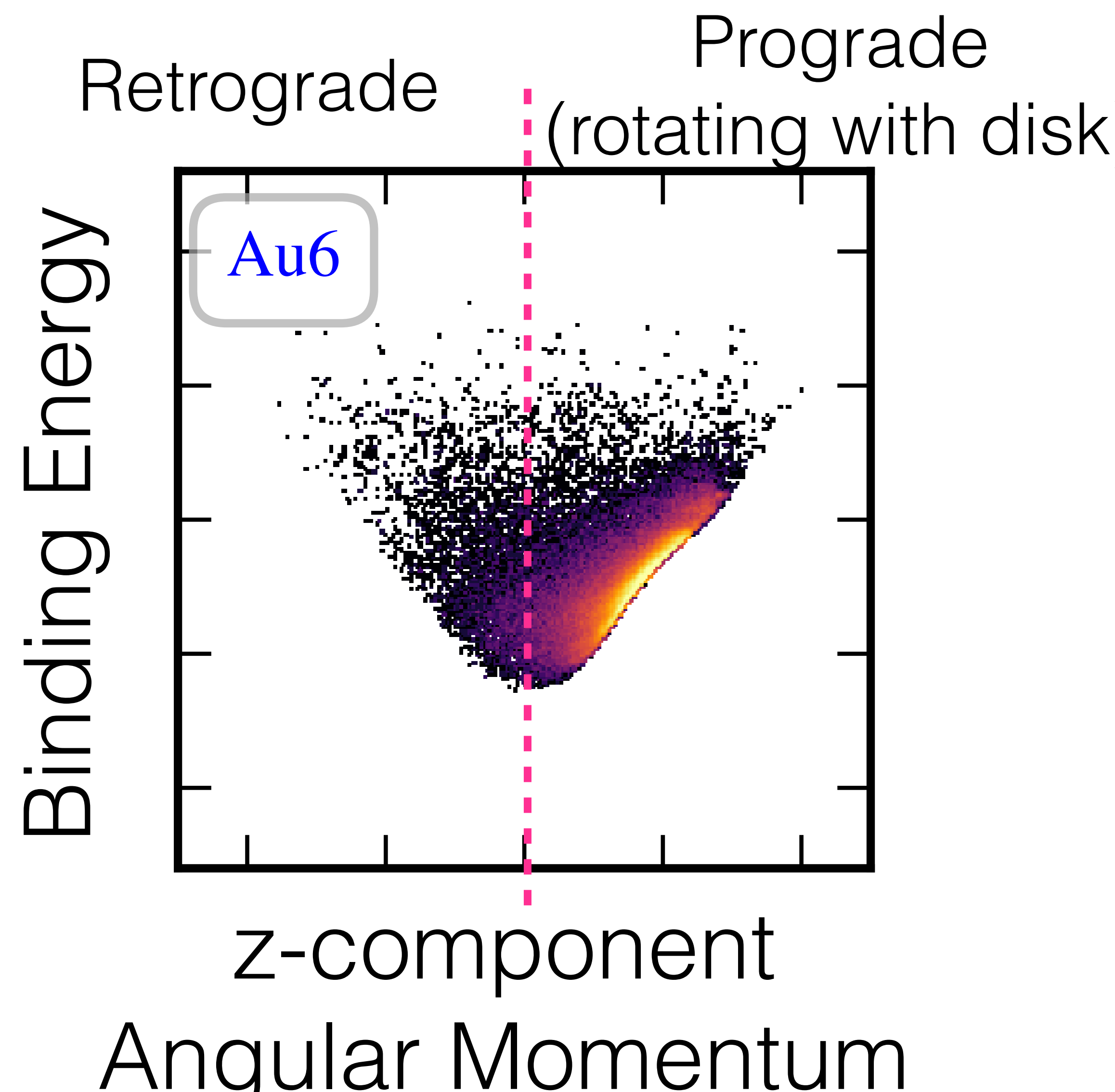
Belokurov et al.

We should expect debris to remain correlated in phase space longer than in position space

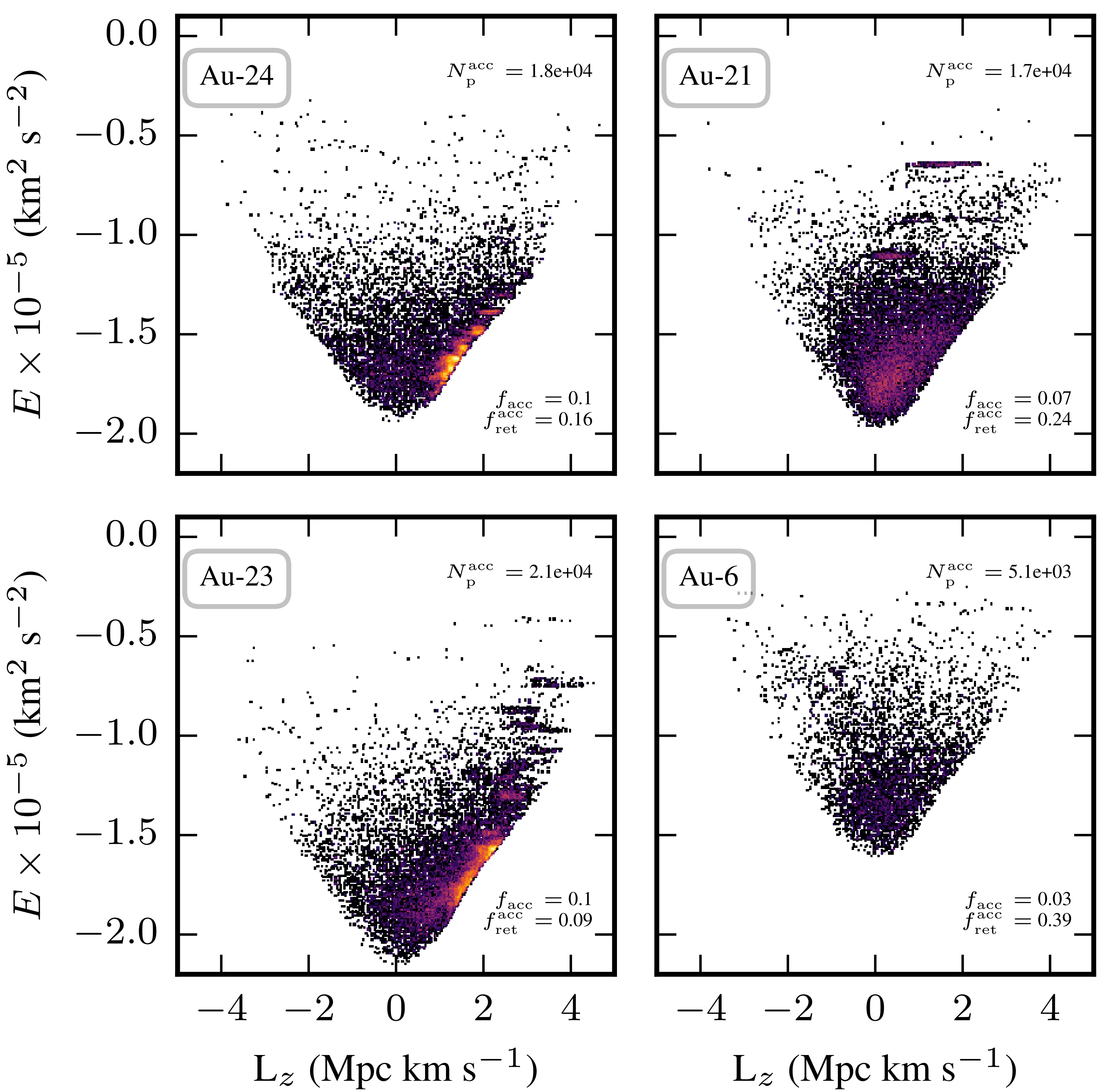
Binding/Orbital Energy:
$E = v^2/2 + \phi$

Angular Momentum:
$\mathbf{L} = \mathbf{r} \times \mathbf{v}$





Accreted material in Auriga shows a diversity of phase space structure

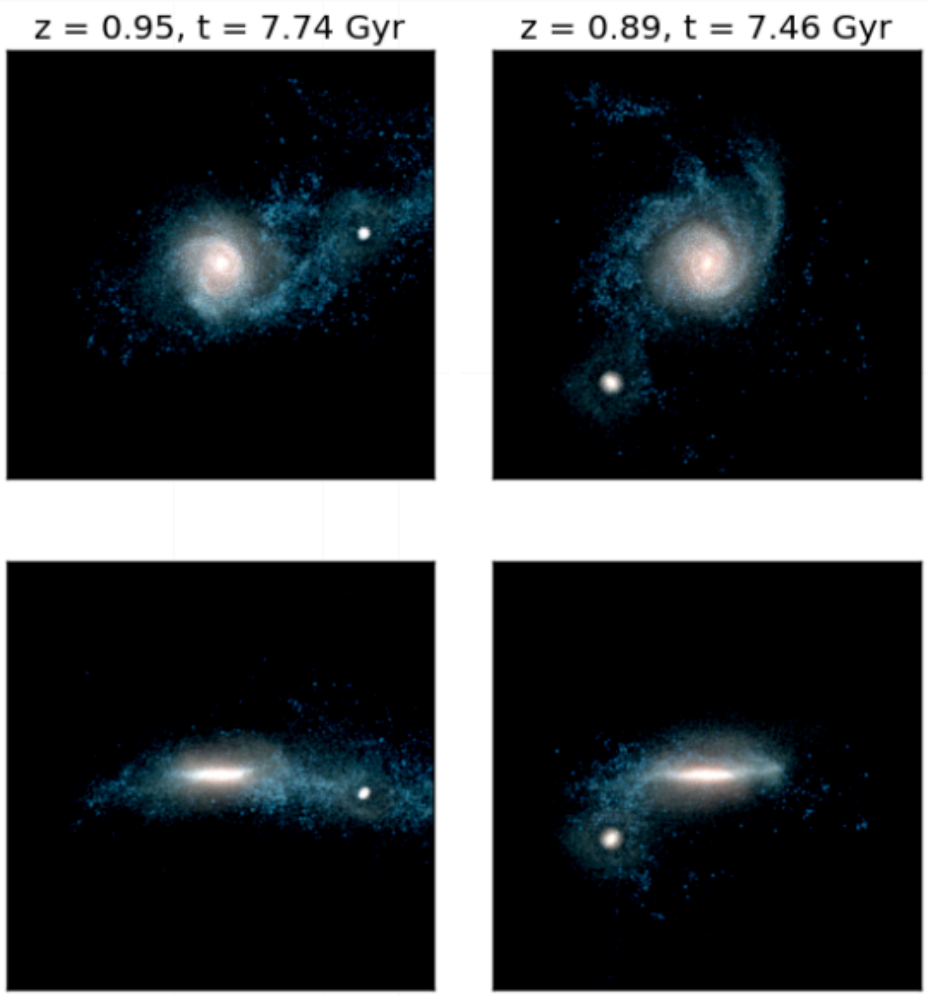


- (Currently) Highest resolution Auriga simulations: 5 x 10^3 M$_\odot$ per star particle
- Accreted stars in 2.5 kpc sphere positioned 8 kpc from center are shown

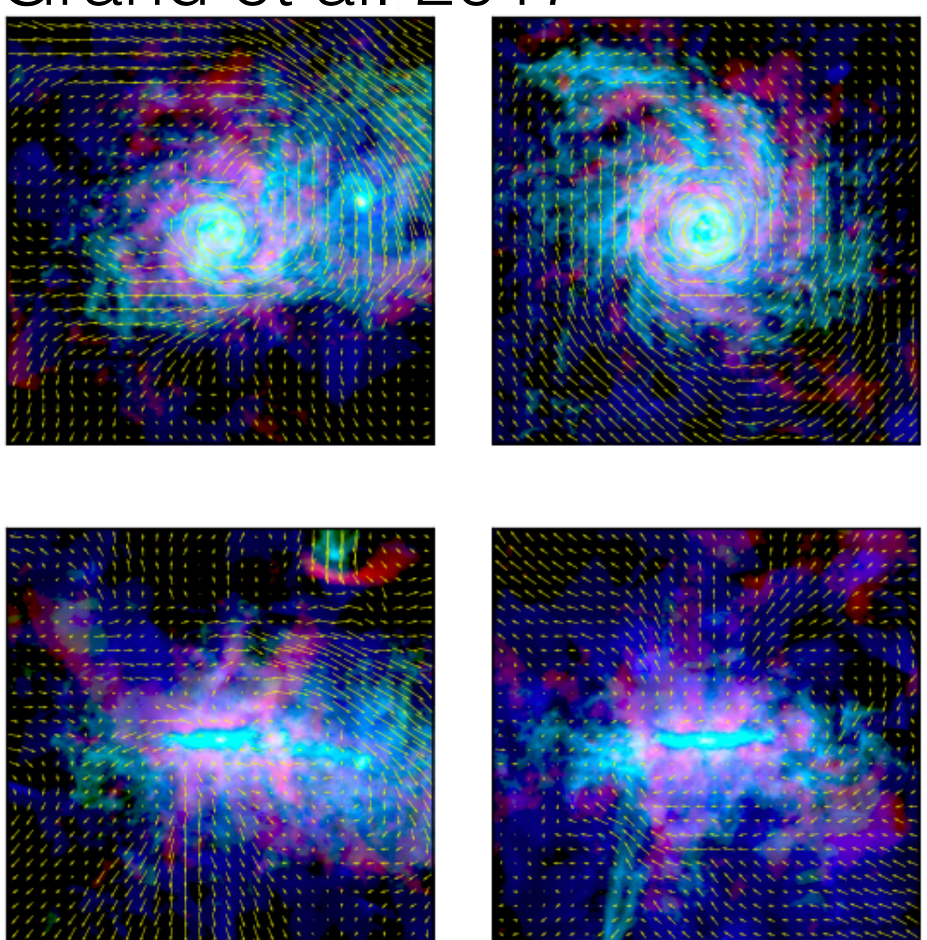
Satellite-Host Disk connection

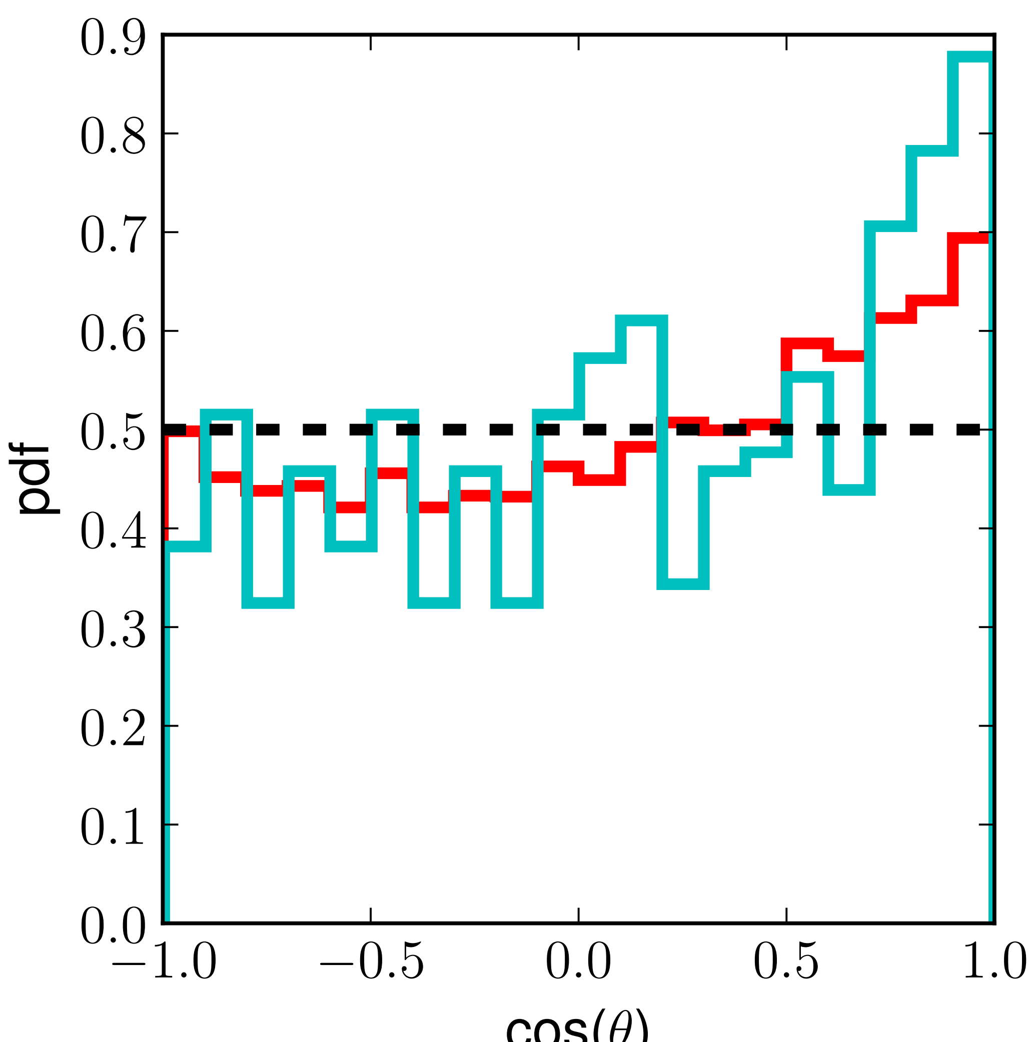
Angle between L_{orb} and $L_{host\text{-}disk}$

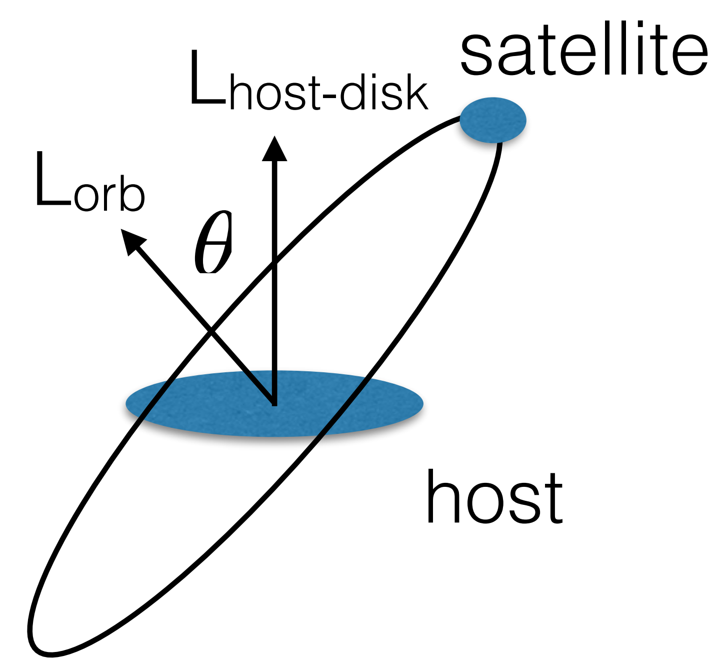
Red: Dark Satellites
Cyan: Luminous satellites



Grand et al. 2017





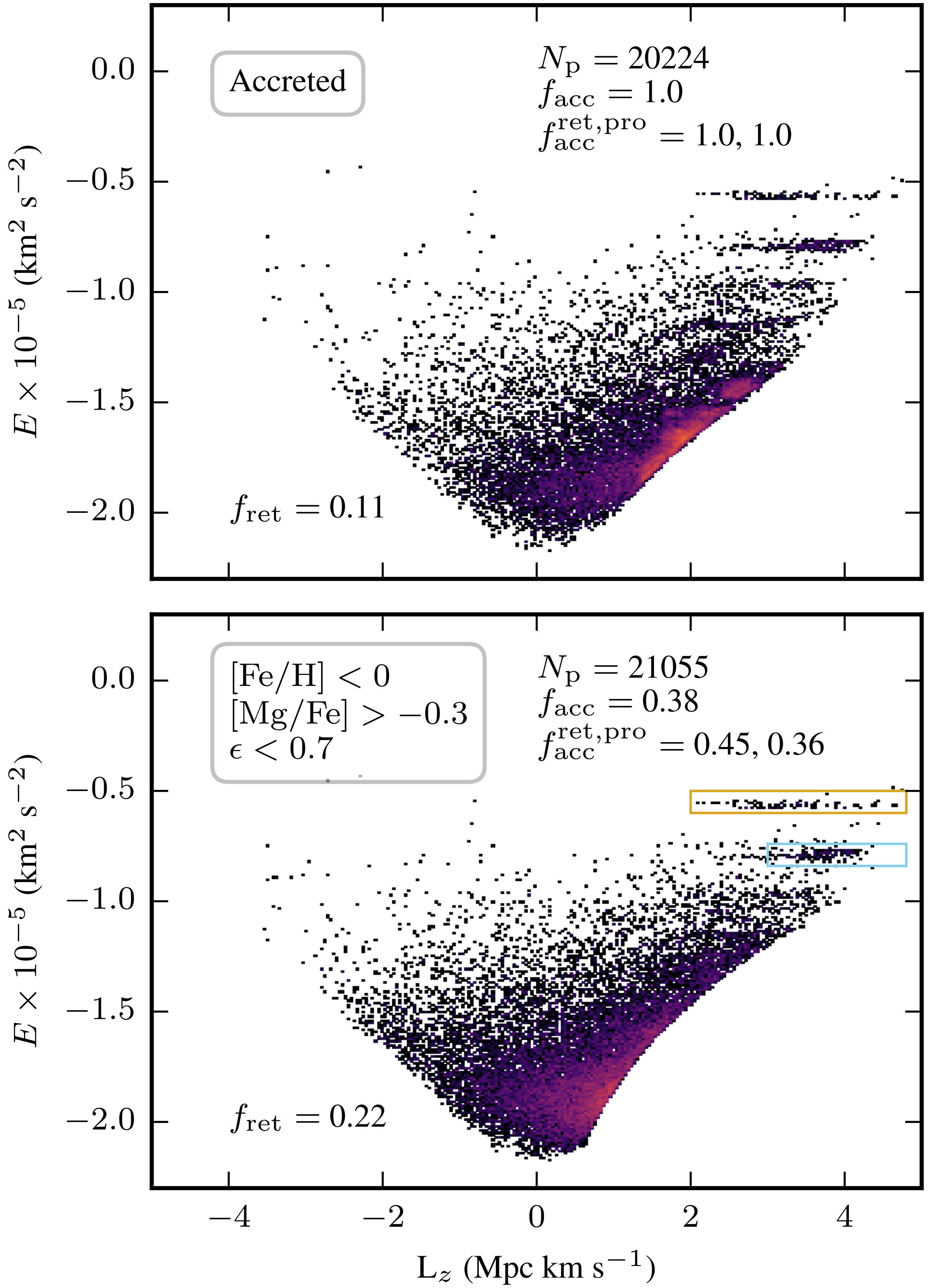


Simpson in prep

Chemical and dynamical cuts (aka GAIA doesn't have accretion flags)

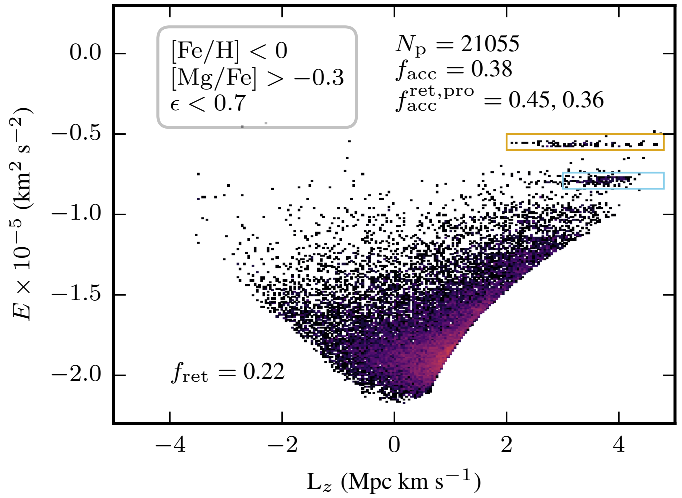
Accreted Only

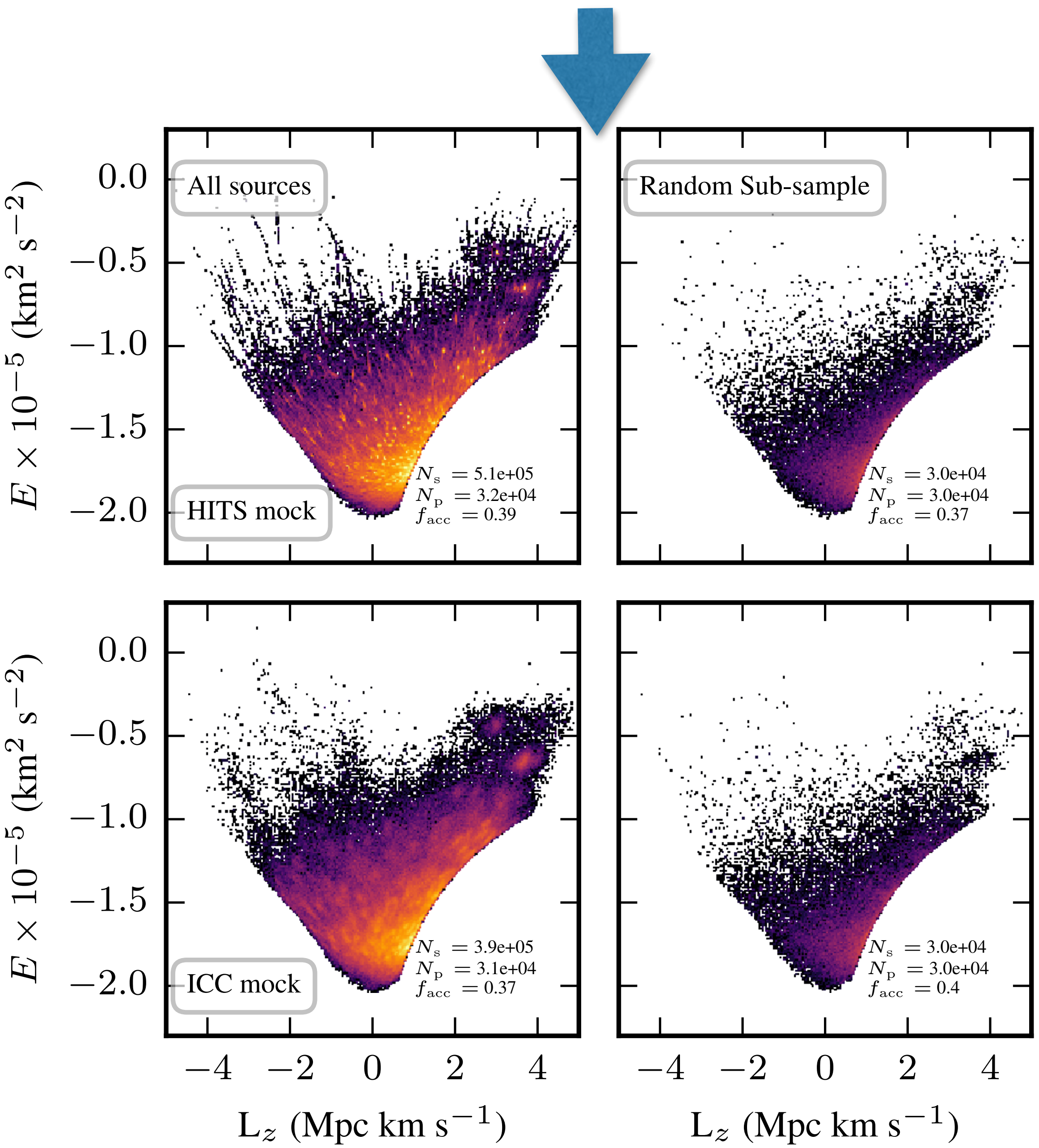
Chemically & Dynamically Selected



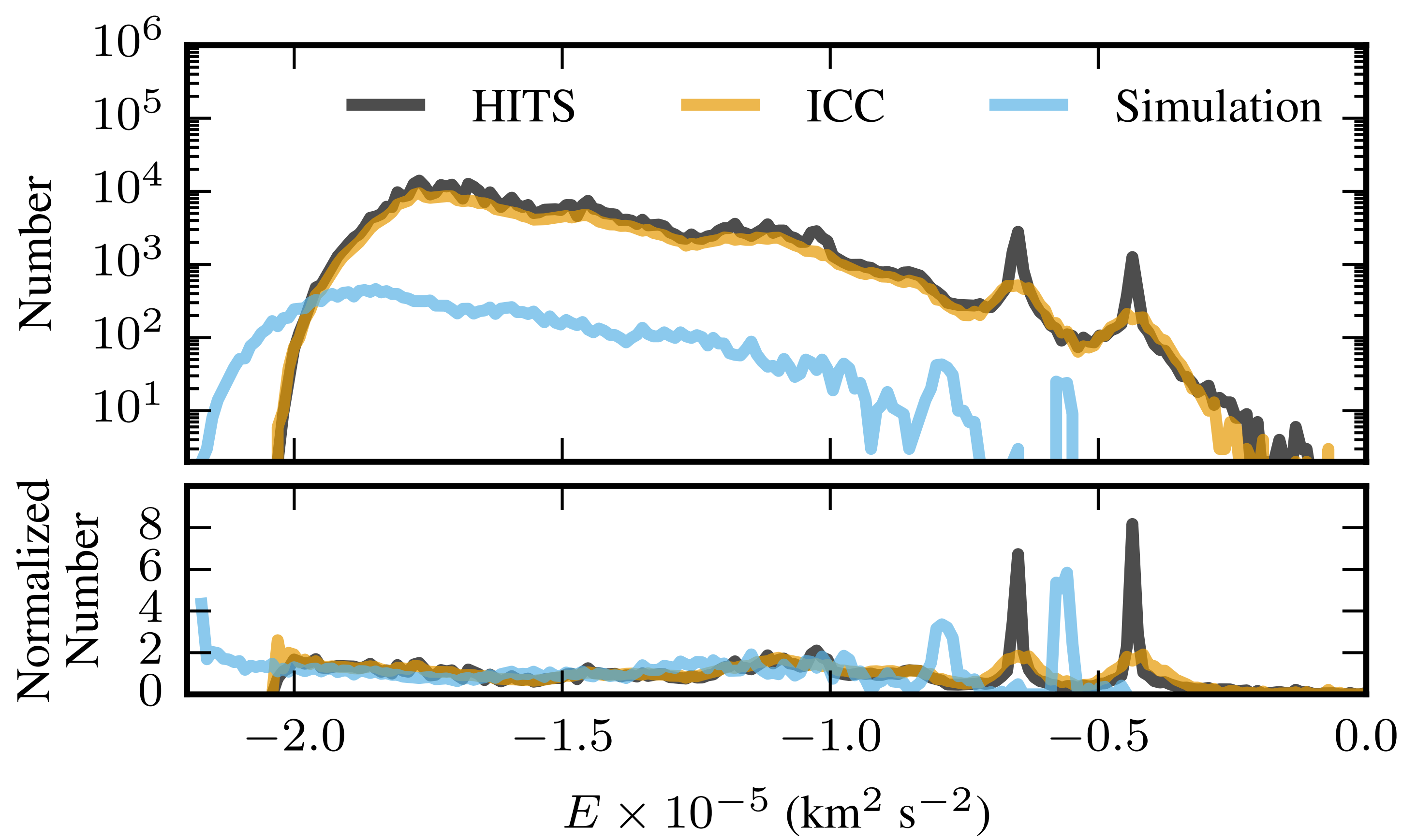
- Apply cuts in Fe, Mg, and circularity
- Structures in this case created by massive satellite (Mstar = 5 x 10^9 Msun) disrupted 3 Gyr ago

Mock Observations: Aurigaia

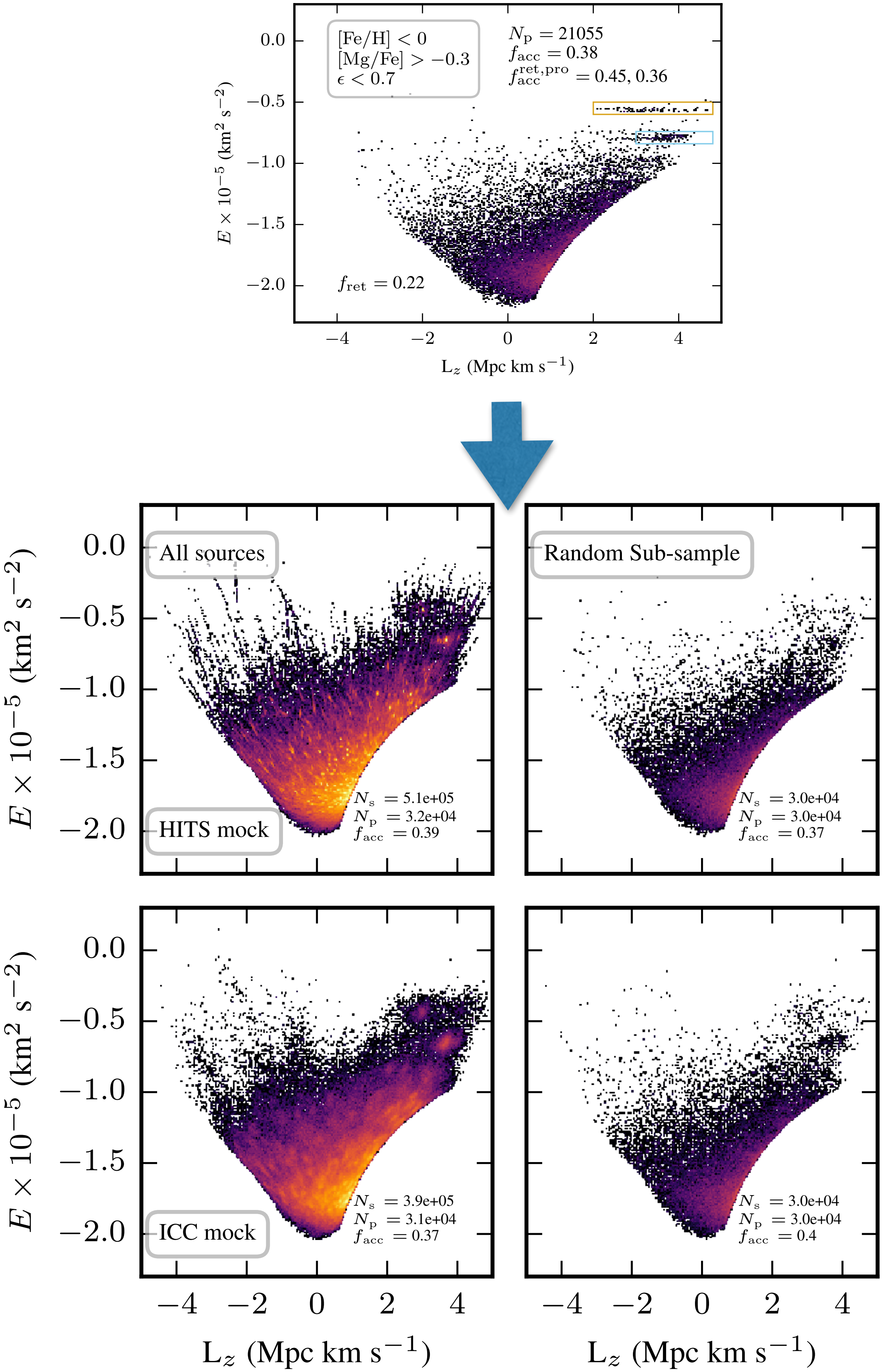




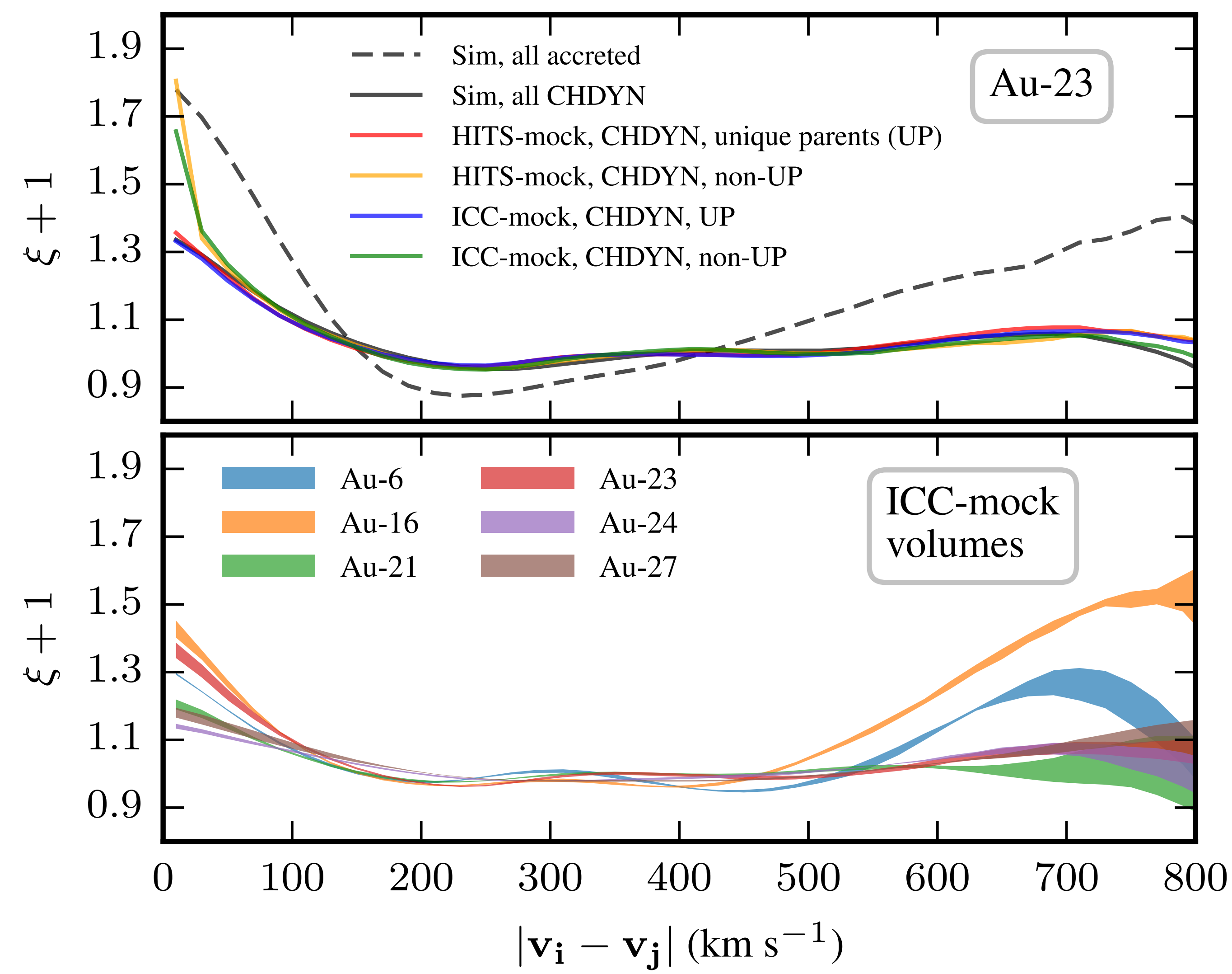
- Use mock-Gaia catalogues of our simulations (Grand et al. 2018).
- Two methods applied with different assumptions about phase space smoothing (HITS,ICC)
- Use a 3 component fit for the galaxy potential with mock (use true potential for simulations)



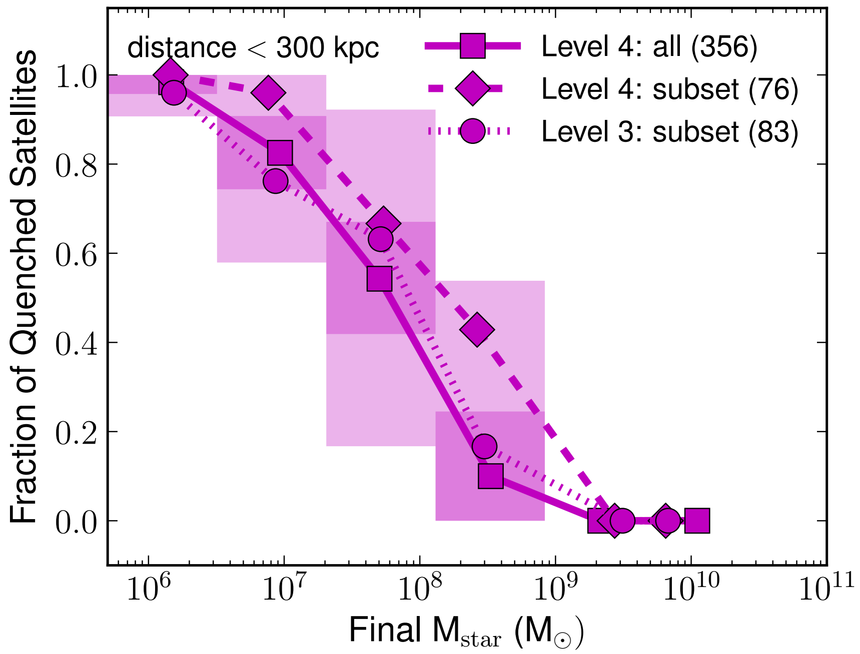
Mock Observations: Aurigaia

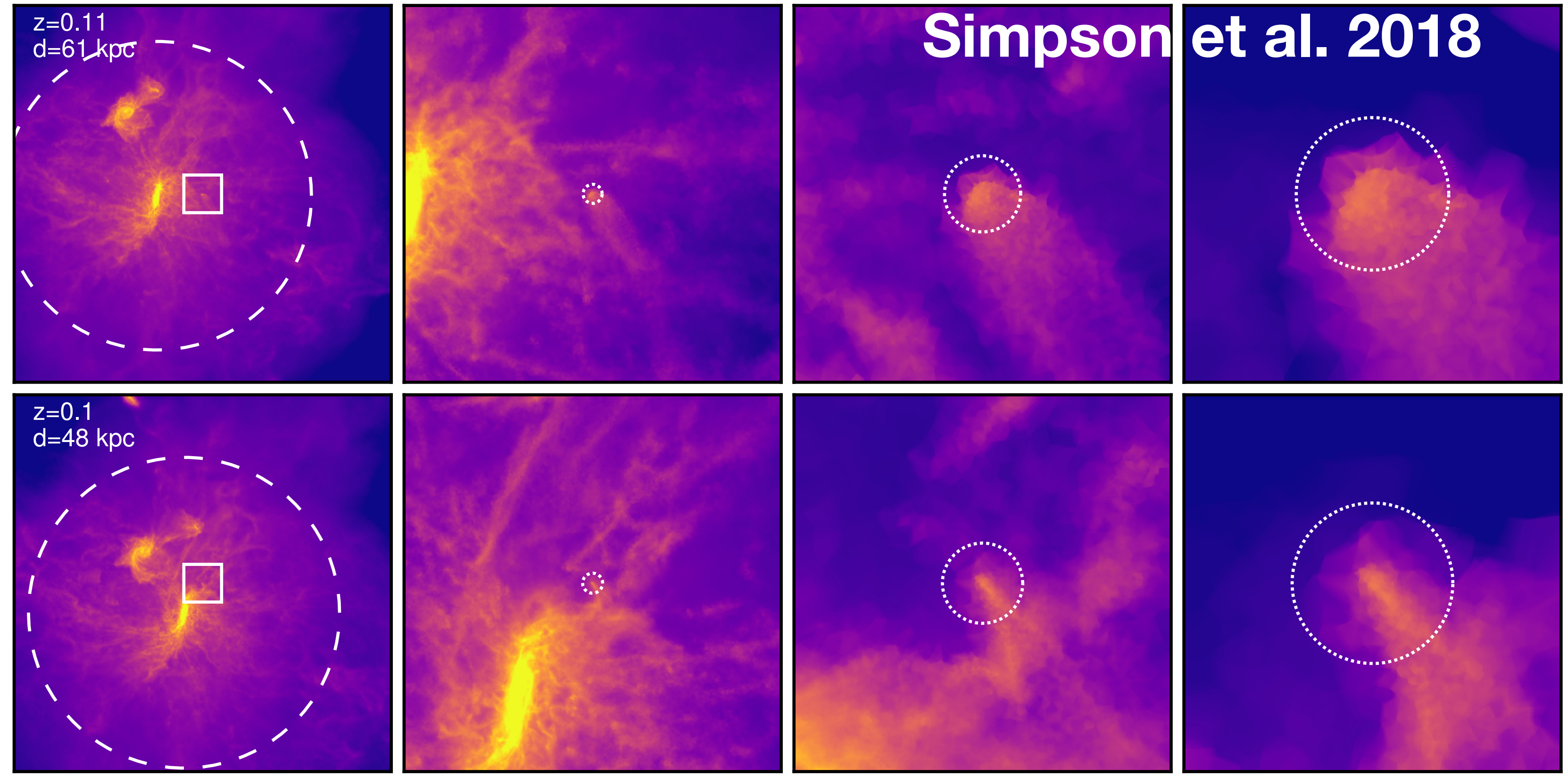


- 2pt correlation functions measure the excess of star pairs as a function of their velocity difference
- Low velocity difference excess doesn't seem to correlate with phase space structures
- High velocity excess does not indicate a counter rotating disk



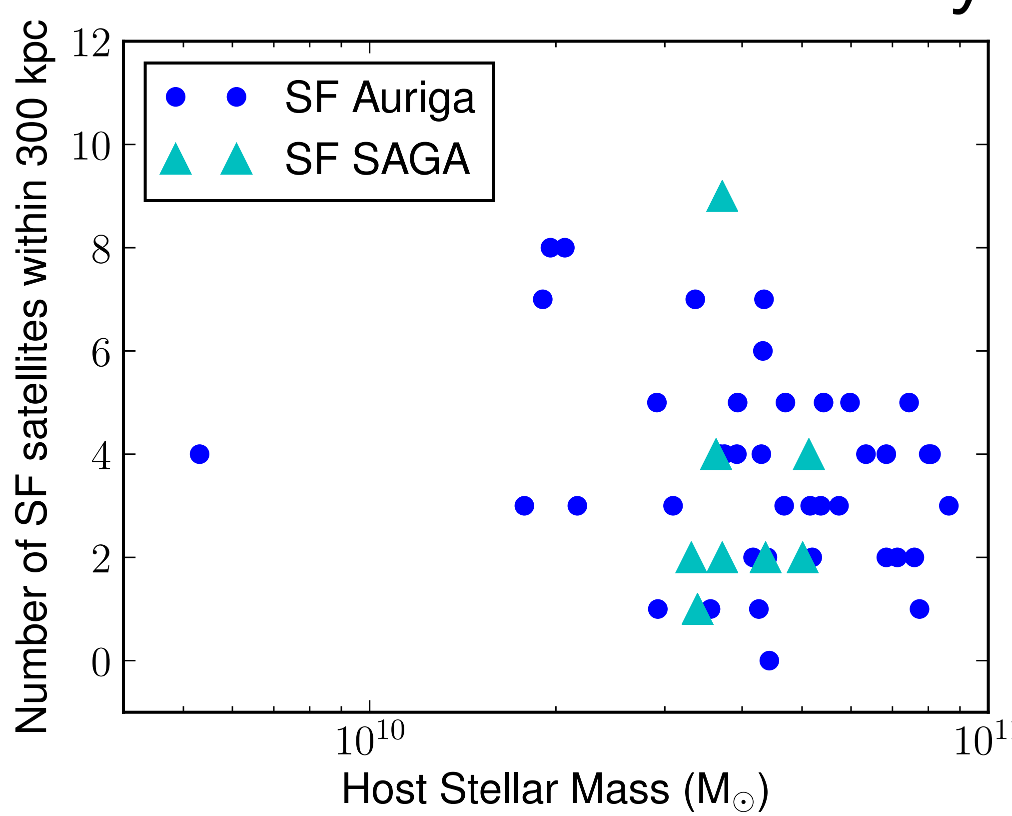
Satellite Quenching in Auriga

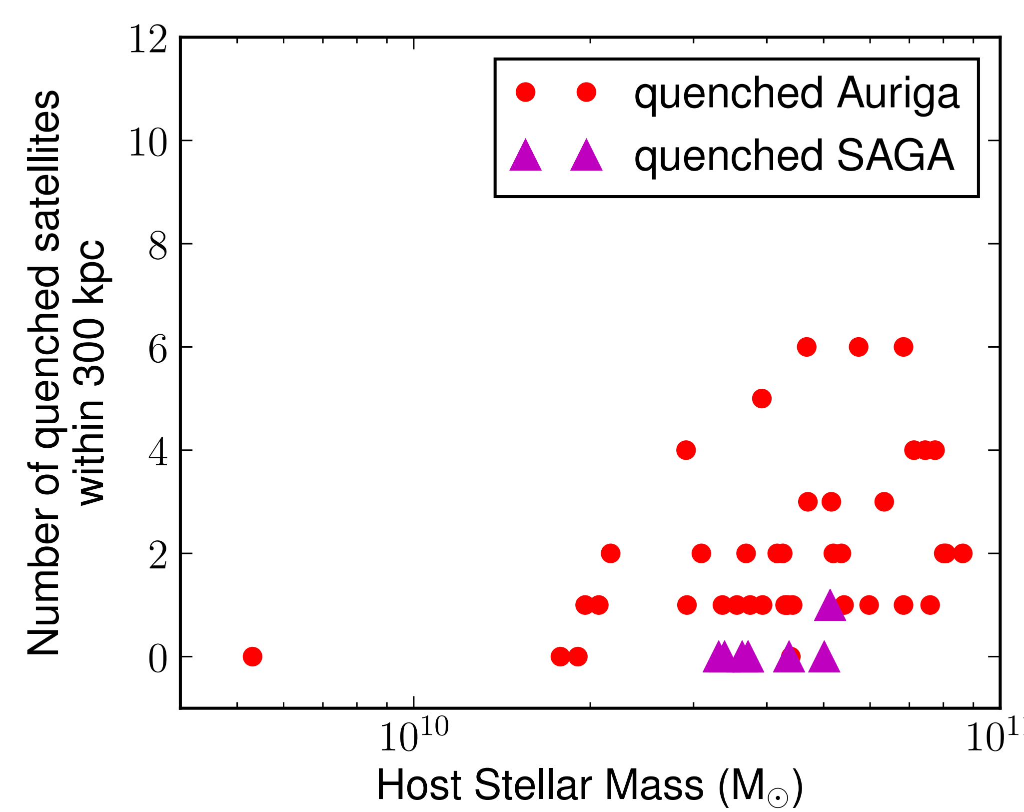




Is the MW typical? The SAGA survey

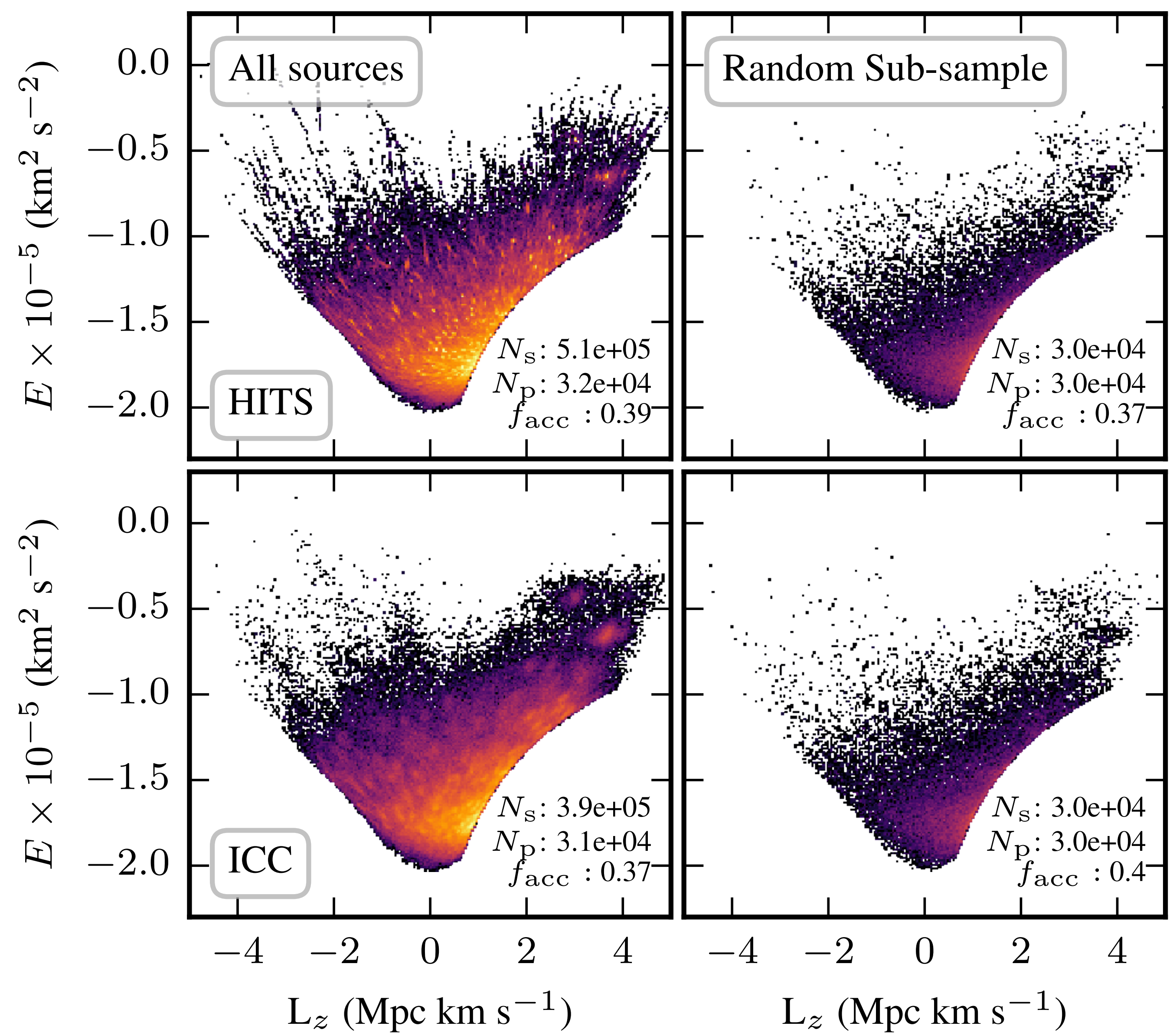
Magnitude Limit: $M_r < -12.3$



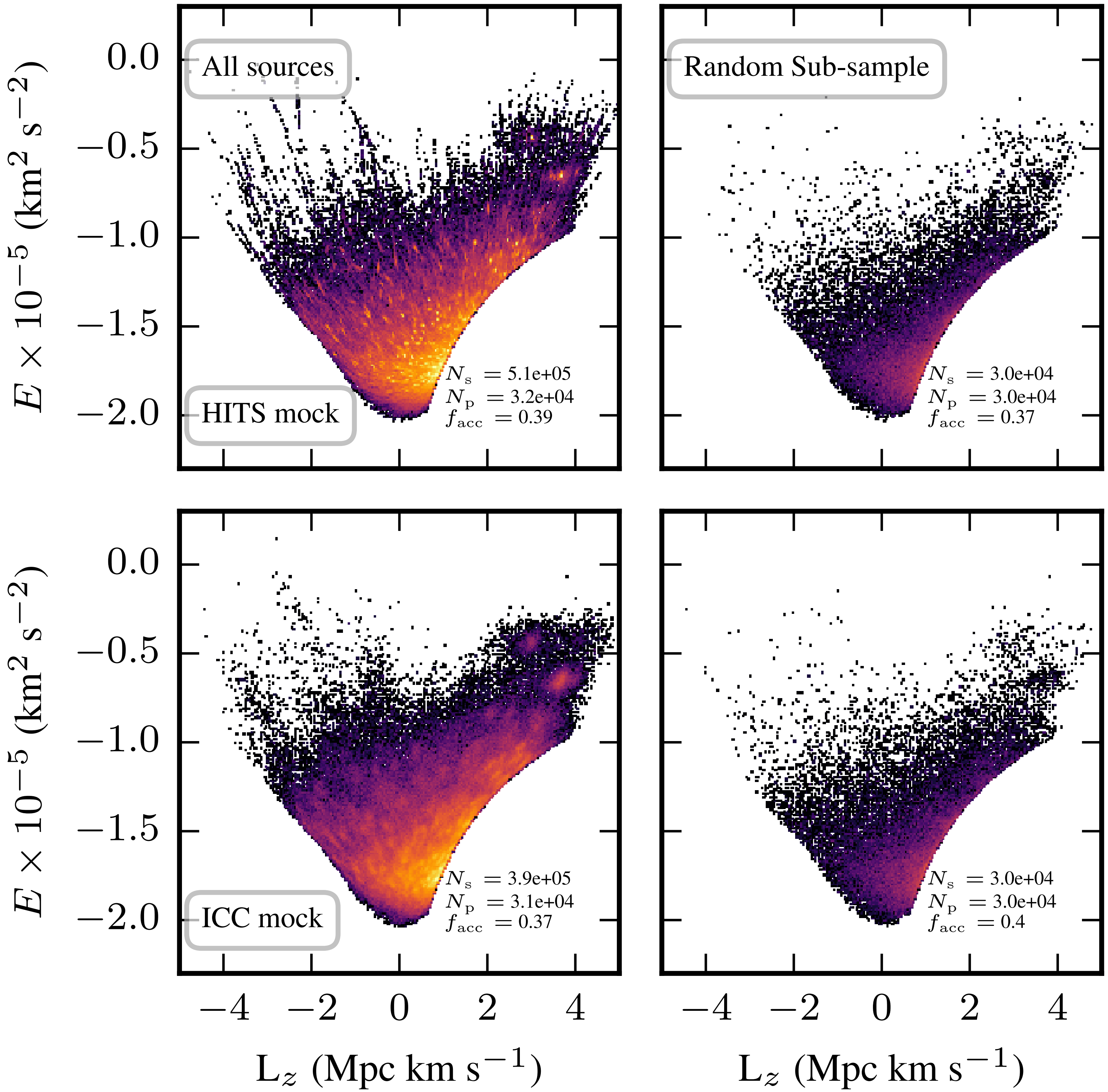


Conclusions

- Auriga hosts satellite debris that can be seen in position & phase space
- There is a diversity in accreted structures between halos
- Mock observations are necessary to make observational predictions, but challenges remain in this step of the process
- Future work will entail connecting debris structures to progenitor properties & orbits and modifying simulations to better capture dynamical mixing



A note on ‘stretching’



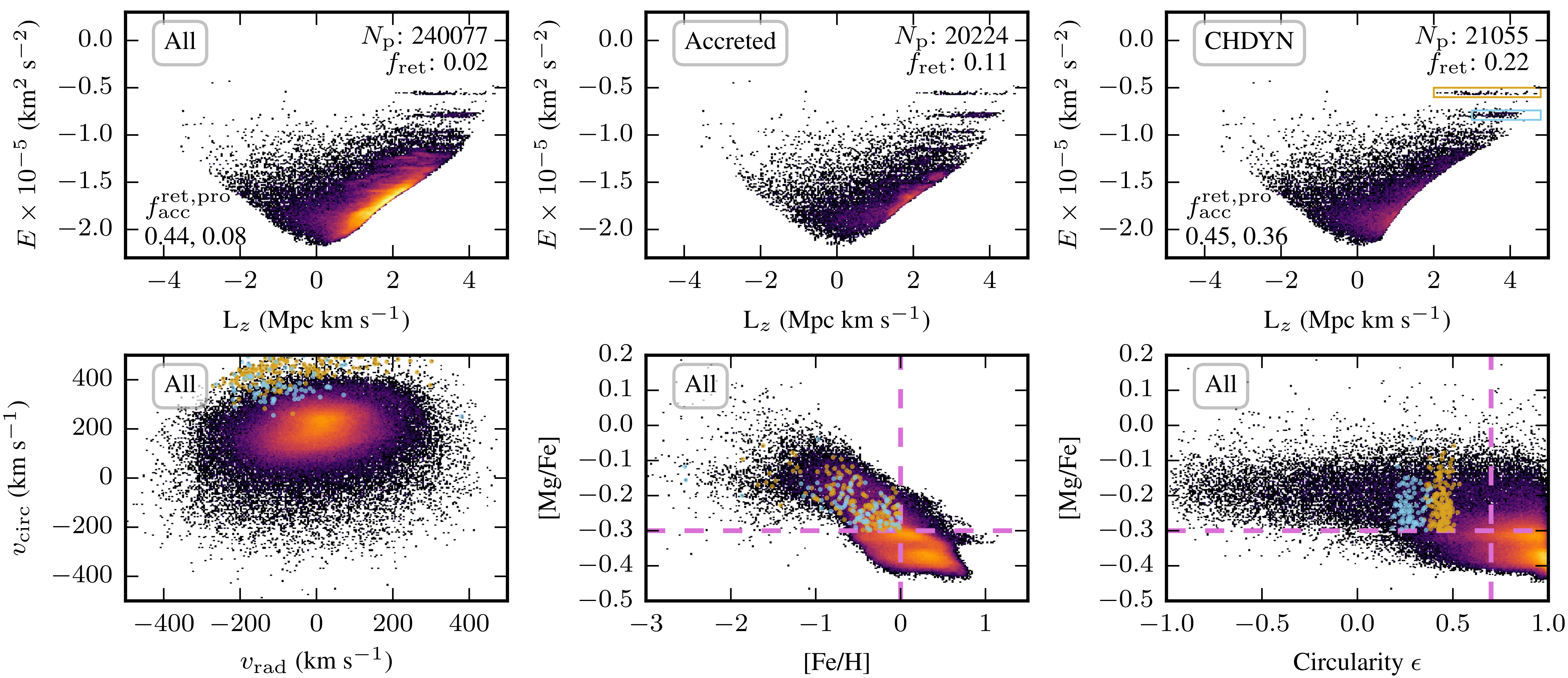
Child star c comes from Parent particle p:

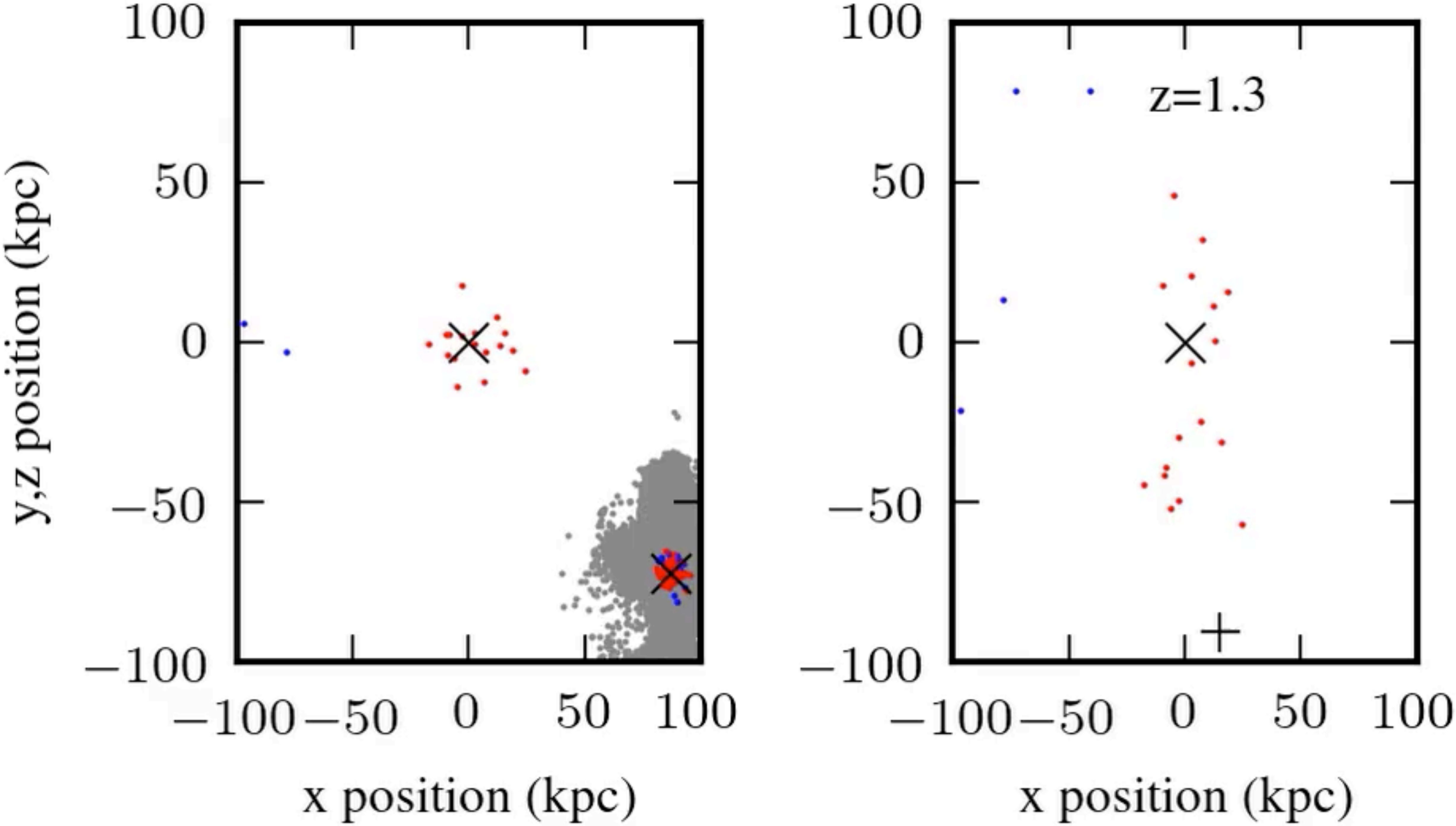
$$\mathbf{r}(c) = \mathbf{r}(p) + \mathbf{dr}$$
$$\mathbf{v}(c) = \mathbf{v}(p) + \mathbf{dv}$$

$$E_{kin}(c) = E_{kin}(p) + \mathbf{v}(p) \cdot \mathbf{dv} + 0.5\, dv^2$$

Even if $E(p_1) = E(p_2)$, the energy of their children won’t be $E(c_1) \neq E(c_2)$

Chemical and Dynamical Selection cuts





100
50
0
−50
−100
y,z position (kpc)
−100
−50
0
50
100
x position (kpc)
z=1.3